TWO EXAMPLES OF SONIFICATION FOR VIEWER ENGAGEMENT: HURRICANES AND SQUIRREL HIBERNATION CYCLES

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1. INTRODUCTION

This extended abstract describes two sets of sonifications that were commissioned by researchers from the fields of meteorology and animal ecology. The sonifications were created with the software synthesis program SuperCollider [1]. The motivation for creating them was to pursue additional levels of engagement and immersion, supplementing the effects of visual plots. The goal is for audiences, in particular students and laypeople, to readily understand (and hopefully find compelling) the phenomena being described. The approach is parameter-based, creating "sonic scatter plots" [2] in the same manner as work described in earlier publications [3-4].

2. HURRICANES

2.1. Description of the Datasets

Sonifications of eleven hurricanes were commissioned by Jenni L. Evans of Penn State's Earth and Environmental Systems Institute. The datasets have a sampling period of six hours, so that each day contains four measurements, taken at midnight, 6:00 AM, 12:00 PM, and 6:00 PM. Each dataset has on the order of 30 data points. For each timestamp there are values for:

- *latitude* and *longitude* of the storm's center;
- *air pressure* – this is the most direct measurement of the storm's intensity, with lower millibar pressure values corresponding to higher storm intensities;
- *asymmetry* – around the storm is a band of varying thickness within which the pressure drops from 900 to 600 millibars; the asymmetry values describe the difference in this band's thickness on the right and left sides of the storm;
- *-VTL* and *-VTU* – degree to which the storm's temperature differs from the surrounding environment, in the lower and upper tropospheres, respectively.

The position and intensity data were obtained from (i) the National Hurricane Center for Atlantic and East Pacific and (ii) the Japanese Meteorological Agency. The asymmetry values were derived at Penn State from information obtained from the European Centre for Medium Range Weather Forecasting.

2.2. Sonification and Sound Design

Satellite videos of hurricanes are publically viewable online at the National Oceanic and Atmospheric Administration [5]. We made screen recordings of eleven videos, using Apple's QuickTime™ Player. The playback rate is variable, and we made a choice to render a seven-day event over a timescale that lasted two to three minutes, depending on the hurricane. After the videos were recorded, we adjusted the datasets so that they matched the starting and ending dates reflected on the videos. Sonifications were then created on a timescale that matched the playback time of the video. These audio files were then added to the corresponding QuickTime files. For a typical animation project, this method would be far too imprecise – it would never work to lip-synch dialog, for example. But given the low sampling rate of these datasets, it is accurate enough. Our videos and accompanying soundtracks may be downloaded at [6].

The sonifications have three layers:

1. A swirling, windy sound was an intuitive choice to represent *pressure* changes. Lower pressure values result in increased speed of the swirls, higher volume levels, and a greater degree of timbral coloration. The stereo pan position changes with changes in *longitude.*
2. The *latitude* is mapped to a high pulsing sound. As the latitude moves from the equator, the pitch drops, which is meant to suggest lower temperatures away from the equator. We tried varying the pulsing speed as well as its pitch, but found that the urgency suggested by an increasing pulse rate was misleading, particularly when heard within the context of the windy sound produced by the intensity data values. So we made the decision to keep the pulsing rate constant, and vary the pitch only.
3. The *asymmetry* values were mapped to a rich harmonic wave that pulsed in volume. Higher asymmetry levels were mapped to higher amounts of harmonic content, which created a richer timbre that sounded higher in pitch, even though the fundamental did not change. The *-VTL* values were mapped to changes in the rate of pulsing, so that lower values produced slower pulses. The *-VTU* values were mapped to the pan position of the rich, pulsing harmonic wave.

2.3. Presentation at Conference and as Museum Exhibit

The datasets are typically studied visually, and the online satellite videos are helpful for studying the shape and position of the hurricanes. When we added the sonifications, listeners have generally found that the added sound dimension enhanced the viewing experience. In at least one case, additional insights were gained through the use of sound. As hurricanes become more visibly symmetric, their intensity rises. However, there are times when the intensity rises without a corresponding change in symmetry, and these occasions can be difficult to discern visually. With the additional sound cues, the intensity changes can be heard regardless of whether or not there is a change in symmetry.

The sonifications were initially prepared for a poster session/reception held at an international workshop [7]. They will also be exhibited in Penn State's Earth and Mineral Science museum starting in June 2015. An interface created in Max/MSP/Jitter will allow museum visitors to select one of the eleven videos. A supplementary screen will provide explanations of the sonifications, with examples of each parameter [Figure 1].

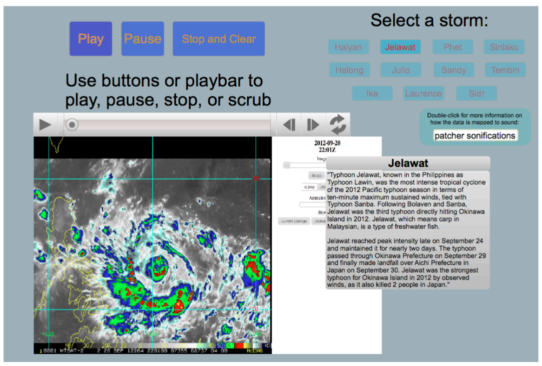

Figure 1: Interface screen for museum exhibit in Penn State's Earth and Mineral Science Museum.

3. SQUIRREL SEASONAL BODY TEMPERATURES

3.1. Description of the Datasets

These sonifications were commissioned by Michael Sheriff of Penn State's Department of Ecosystem Science and Management. His work involves the study of arctic squirrels in order to better understand how their dates of hibernation and reproduction affect their larger ecosystems [8].

The data is collected by surgically implanting squirrels with temperature sensors, which track their body temperatures until the sensors are removed a year later. The datasets consist of timestamped body temperature measurements, which are taken every 34 minutes. Each dataset, describing approximately 12 months of body temperature changes, consists of some 15,000 values.

During active periods, their body temperatures undergo daily cycles. In the fall, the squirrels go underground, where they eventually hibernate. At first, they are conscious for a period of time, although in a state of sensory deprivation. Their body temperatures become irregular in the absence of cyclical changes in sunlight levels. During hibernation, they enter a state of torpor, which is characterized by inactivity and a drastic drop in body temperature. Torpor is interrupted by brief arousal intervals, where the body temperature returns to euthermal (active) levels in a series of short spikes. Following hibernation, the squirrels remain underground for a period of days before returning above ground, when the cyclic changes resume almost immediately [Figure 2].

3.2. Sonification and Sound Design

Four datasets, a male and a female from two arctic locations, were sonified. The sonification design consists of a ringing filter, which transforms an impulse signal into a sound resembling a handbell. Thus, each data point is considered a scaled impulse that "rings" a bell. The iteration rate is such that temperature activity spanning a year's time plays over six minutes of listening time. This high iteration rate blurs the "rings" into a throbbing, buzzing sound. This was an aesthetic choice meant to suggest heat levels. Data values control both the pitch and volume, such that at higher temperatures, the pitch is higher and the volume is louder.

During active periods, a subtle throbbing can be heard, which reflects daily temperature cycles. The lower hibernation temperatures are mapped such that the pitch drops an octave and a half to reflect the lowest temperature levels. The differences between torpor and euthermal levels are readily audible, just as they are readily visible in graphs. What emerge most clearly in the auditory renderings are the irregular cycles that occur just before and after hibernation. Audio examples may be heard online at [9].

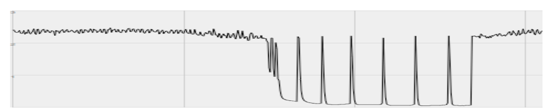

Figure 2: Twelve months of body temperature changes in a male adult squirrel from Toolik, Alaska.

3.3. Intended Audience: Secondary School Students

Professor Sheriff intends to use the sonifications in outreach programs he presents to school children, who sometimes have difficulties engaging with visual graphs such as Figure 2. The groove-like quality of some of the temperature cycles should be immediately apparent, and hopefully appealing. The aim is for the sonifications to make the cyclic and quasi-cyclic qualities readily understandable to these young audiences.

4. REFERENCES

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[3] M. Ballora, "Sonification, Science and Popular Music: In search of the 'wow,'" *Organised Sound*, vol. 19, pp. 30-40, April 2014. doi:10.1017/S1355771813000381
[4] M. Ballora, "Sonification Strategies for the film Rhythms of the Universe." Presented at the 20th International Conference of Auditory Display (ICAD 2014), June 22-25, New York, NY, USA.
[5] http://rammb.cira.colostate.edu
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